specific energy

Definition:

The thermodynamic energy per unit mass of an object.

Units:

J/kg (joule per kilogram)

Background Notes on Measures - 3

Additional information can be found in the Dictionary of Units

ENERGY

Work is done when an object is moved by a force.
Two things need to be measured: the amount of the force and the distance that it moves. Multiplying these two together (Force × Distance) gives the numerical size of the work done. The units for this work are derived by combining the units used to measure the force and the distance.
Thus, if the force is measured in 'newtons' and the distance in 'metres' then the work is expressed in newton metres [Nm]. This is the SI preferred unit of work.

The most useful and practical definition of **energy** is that it is
'a measure of the capacity for doing work'
Energy comes from many sources - sunlight, wind, water, coal, oil, gas etc., and is of many types: thermal, electrical , chemical, nuclear etc.
Because there were so many forms of energy, several ways of measuring it were developed over the years, each being the one that seemed most appropriate to the form of energy under consideration. Thus heat was measured by how much of it was needed to warm up some water (the British thermal unit) while water-power was measured by finding out how far it would lift up a weight (the foot pound).
It was only during the 19th century that the connection between the two was established in a famous experiment by J P Joule (English physicist 1818-1889) when he showed that
778 foot-pounds was the same as 1 British thermal unit
Once this was understood it became possible, for the first time, to compare the various forms of energy; as for example, comparing water-power with coal.
It is in his honour that the SI standard of work (or energy) is named the joule [with the symbol J] which is equivalent to 1 Newton metre [1 Nm]. Since the joule is a rather small unit, kilojoules [kJ] and megajoules [MJ] are more usually seen in practice rather than joules.

It will be noticed that Energy, Work and Torque all seem to share the same units.
Torque is dealt with later in this document.
Work and Energy are merely different ways of looking at the same thing. It is a matter of language and usage rather than of physics.
The word 'energy' tends to be used when referring to the potential of something to do some work, while the word 'work' is used after (or during) the work has been (or is being) done. But there are no hard rules about this.

The 'erg' might be unfamiliar to many. It is of historic interest only. A relic of the old cgs (centimetre-gram-second) system. It is a very small unit of energy indeed. A joule is not very big, but it is equal to 10 million ergs!

Caution
Some of the units named here have more than one definition!
First there are: calories (and kilocalories), British thermal units (and therms). Full details of the different values possible for each can be found under the entry for 'Energy' in the main Dictionary of Units. The values used in the calculator are those of the International Table.
Second is horsepower which can, in fact, take 5 different values. Again, details are to be found under the entry for 'Power' in the main Dictionary.
Generally, the values used in the calculator will serve for most purposes but, for extremely accurate work, care needs to be taken.

Go to the ENERGY Conversi n Calculator

SPECIFIC ENERGY

This is a measure of the amount of energy contained in a unit quantity of some substance. It is also known as
Calorific Value
The energy content can be expressed in any units of energy: Btu, calories, joules, watt-hours etc. The preferred unit is joules with the appropriate range of prefixes for kilojoules [kJ] megajoules [MJ] and so on. The unit quantity may be either of mass (pounds or kg) or of volume (cubic feet or metres). It really depends upon the nature of the substance. For solids it is usual to use unit mass, and for gases to use unit volume (together with a statement of the pressure and temperature). For liquids, either mass or volume can be used.

The approximate Specific Energy values of some solid fuels are

Coal	23 to 35 MJ/kg
Wood	16 to 21 MJ/kg
Peat	23 MJ/kg
Charcoal	28 to 33 MJ/kg

The approximate Specific Energy values of some gas fuels are

Coal gas	19 to 22 MJ/m^3
Natural gas	37 MJ/m^3
Acetylene	56 MJ/m^3
Propane	93 MJ/m^3
Butane	110 MJ/m^3

All based on a particular pressure and temperature.

Petrol is about 33 MJ/litre.

Nuclear energy is totally different in both the method of production and the scale of the released energy. As a very rough guide, the fission of a given mass of a suitable material (such as plutonium) produces something of the order of 3 million times the energy obtained from the same mass of an 'ordinary' fuel such as coal.

Caution Some of the units named here have more than one definition! See the note under Energy (above) for details

LATENT HEAT

Generally, all matter can be considered to exist in three states:

solid, liquid, gas.

One example is water which has the three states:

ice, water, steam.

Any change between these is known as 'changing state', and requires a change in the energy level. The amount of this change of energy is known as the **Latent heat**.
A change between liquid and solid (in either direction) is the

latent heat of fusion

between liquid and gas it is the

latent heat of vaporization.

In other words, latent heat is the amount of energy involved (putting it in or taking it out) in bringing about a change of state *without any change in temperature.*

Latent heat is usually stated as energy per unit of mass. So it has the same units as Specific Energy (by mass), but is not the same thing.
The preferred unit is **J/kg** (joules per kilogram).
As an example consider water. It can be cooled down by extracting heat from it until it reaches 0°C and no lower. After that it must change state into ice. This requires further cooling, taking out 333 kilojoules from every kilogram (**333 kJ/kg**) of water to produce ice which is still at 0°C. Only then will more cooling produce a further drop in temperature.
A similar thing happens at the boiling point 100°C when it requires 2250 kilojoules per kilogram (**2250 kJ/kg**) of water to change it into steam.
(The figures given are not exact and vary with pressure.)

Go to the SPECIFIC ENERGY (by Mass) Conversion Calculat r

or the SPECIFIC ENERGY (by Volume) Conversion Calculat r

FORCE

A **force** produces a change in the motion of an object. For example, if an object is at rest then a force is needed to make it move. If the object is moving then a force is needed to change either its direction of movement or its speed of movement, or both.
Change in the movement of an object is an **acceleration** which may be positive or negative.
The size of the force is measured by

the **MASS** of the object × the **ACCELERATION** produced by the force.

The SI unit of force is the newton which is named after the English mathematician Sir Isaac Newton (1642-1727).

Different units of force have been defined and used over time.
There is usually confusion over **WEIGHT** (which IS a force) and **MASS** (which is NOT a force). Hence the reason for putting a small 'f' on some units.
So, a 'kgf' is a kilogram-force which different to a 'kg' which is a kilogram-mass, and so on.
kilopond is another name for a kilogram-force
sthène is another name for a kilonewton.
kip is a US measure of force equal to half a ton(US) force or 1000 pounds-force.
dyne is a relic of the old cgs (centimetre-gram-second) system. It is a very small unit of force indeed. 1 newton is

He it was who established the basic principles of gravitation, which is a force, after watching an apple falling from a tree. (Why did it fall to the ground and not go upwards? or any other direction?)
A **newton [N]** is the force required to produce an acceleration of

1 metre/second^2 in a mass of 1 kilogram

equal to 100000 dynes
poundal belongs to the old fps (foot-pound-second) system.

The value of 'g' (acceleration due to gravity) on which several of the units depend is exactly 9.80665 m/s^2 in the SI system or about 32.17405 ft/s^2

Go to the FORCE Conversion Calculator

TORQUE

Torque is a measure of the 'strength' being used in turning (or attempting to turn) something.
A common example is that of a spanner being used to move a nut. A force is being applied at one end of the spanner. That force is multiplied by the distance between it and the turning-point (which, in this case, is the centre of the nut) to give a measure of the torque which is being applied.
This seems to be the same as for work which is also:

a force being multiplied by a distance

but look closely, in the definition for torque there is no mention of the force moving as there is in the full definition for work.
So, they are different things even though the units are the same, and no work is done until, in this case, the spanner moves - and even then it is a matter of how far the force moves, and not its distance from the centre.

A distinction used to be made in the imperial system by expressing torque as say, 'pounds feet' and work as 'foot pounds' but the SI does not do this. The SI preferred unit for torque is newton metres [Nm] and for work is joules [J].
Some abbreviations that may not be familiar are

kgf *for* kilogram-force

lbf *for* pound-force

ozf *for* ounce-force

For 'poundal' and 'dyne' see under force.

Go to the TORQUE Conversion Calculator

Go to the the top **OR the** Dictionary of Units **OR the** Calculator Menu